WATER-IN-OIL ANALYZER
PREPRODUCTION INITIATIVE
TEST PLAN

SITES: NAS JACKSONVILLE, FL
NAVAIR PATUXENT RIVER LABORATORY
PHILADELPHIA NAVAL SHIPYARD LABORATORY

1.0 OBJECTIVE

The objective of this Pollution Prevention Equipment Program (PPEP) Preproduction Initiative is to determine the feasibility of extending the life of hydraulic oils by analyzing them for water content using a hand-held water-in-oil analyzer. The initial assessment of the analyzer's capabilities with respect to helicopter transmission oil will be conducted in conjunction with a separate initiative (the Helicopter Transmission Fluid Purification Unit [HTFPU] Preproduction Initiative) at Naval Air Station Jacksonville (NAS JAX). This test plan will address the specific procedures that will be used to determine the water analyzer's ability to determine water content in helicopter transmission oil (MIL-L-85734) in the fleet. If the test is successful, fleet personnel will be able to determine the concentration of water in helicopter transmission oils, and the use of the water-in-oil analyzer will reduce the need for a laboratory to analyze the water content of oil samples.

In addition, the water-in-oil analyzer will be tested in a Navy laboratory setting for its ability to augment the automated Karl Fischer coulometric titrator (Aquatest 8) in determining water content in hydraulic oils (e.g., MIL-L-83282 and MIL-H-17111).

Specifically, the unit will be evaluated on its ability to:

- Accurately determine the concentration of water in transmission and hydraulic oils.
- Reduce or eliminate labor associated with the laboratory analysis of water content in transmission and hydraulic oils.
- Reduce the quantity and disposal cost of hazardous waste generated by the laboratory analysis of the water content of transmission and hydraulic oils.
- Reduce aircraft and support equipment (SE) downtime.

2.0 DESCRIPTION

As part of an ongoing effort to eliminate waste and reduce pollution, the Navy has been exploring the feasibility of extending the operational life of transmission and hydraulic oils. Although the Navy has identified fleet-based tools for measuring particle contamination in transmission/hydraulic oils, no such tool has been identified for the analysis of water content. Consequently, current life-extension efforts require that samples of the oils be collected and sent to a laboratory (usually offsite) for analysis. The turnaround time for this sampling and lab analysis process can be as long as 3 weeks. Not only does this process result in extra costs and the generation of lab-related

hazardous wastes, but it also means that needed aircraft and SE must either remain inactive while awaiting test results or operated under what may be unsatisfactory conditions.

When introduced into aircraft and SE transmission and hydraulic systems, water breaks down the protective properties of the oils. Water entry can occur through physical intrusion as well as through condensation of atmospheric humidity. When aircraft and SE are operating over water or at sea, water intrusion—more specifically, saltwater intrusion—is an even greater possibility. Identifying an accurate method of determining the level of water contamination in both transmission and hydraulic oils is essential to the implementation of an effective oil extension program. The ability to perform accurate water content analysis in the fleet would allow purified transmission oil to be returned to service more quickly. In addition, an accurate dielectric-based test unit would reduce or eliminate the need for the wet-chemistry laboratory analysis (e.g., Karl Fischer) of purified oil and the hazardous waste that is generated by such tests.

3.0 TEST PLAN

This test plan is designed to collect data that will be used to evaluate the efficiency, effectiveness, and performance of the hand-held water analyzer, as well as its compatibility with Navy operations. The test plan will also quantify the capital and operating costs of the analyzer and the waste reductions achieved. These figures will then be used to gain an accurate picture of the costs and benefits that would be expected following a fleet-wide implementation of a transmission/hydraulic oil recovery program that employs this unit.

Two hand-held water analyzers manufactured by Pall Aeropower Corporation have been selected for evaluation in this test: the WS04 portable water analyzer (WS04) and the TD513 series water analyzer (TD513). The WSO4 hand-held water analyzer will be fleet-tested during Phase II of the HTFPU Preproduction Initiative. The hand-held analyzers will also be tested at a NOAP lab to determine if they are capable of augmenting testing done with the Aquatest 8 system currently used to analyze the water content of hydraulic oil samples. Both Pall units are hand-held units (dimensions of 4.6” x 8.5” x 3.0” and 3.6” x 5.75” x 3.0”) that can be programmed to read water content in parts per million (ppm) for specific types of oil. The probe attached to the water analyzer will be used to obtain snapshot readings of the water concentration in the oil.

If repairs to the portable water analyzers are required at any time during the test period, they are to be arranged through PPEP, not the vendors. Call Donna Switzer (856-667-6770) or Raymond Wendrzycki (732-323-1666 or DSN 624-1666) if any consumables or repairs are required for the portable water analyzers.

3.1 Approach

In order to meet the objectives of the plan, several operations will test the hand-held analyzers. NAS JAX squadron personnel will utilize the hand-held analyzer in conjunction with the HTFPU. After determining the water concentration in each sample using the analyzer, NAS JAX will then send a lab sample to the Fuels and Lubricants Division located at Naval Air Warfare Center Aircraft Division Patuxent River (NAVAIR PAX) for laboratory confirmation.

NAVAIR PAX will confirm the results from the hand-held analyzer by using the Aquatest 8 to test the lab samples taken during the HTFPU program. NAVAIR PAX will also use the hand-held sensor to try to duplicate results documented by NAS JAX. Additionally, NAVAIR PAX will spike other types of oils for known levels of water. The NOAP lab in Philadelphia will test many incoming samples with the hand-held analyzer and compare the results to the Aquatest 8 method, in addition to spiking other types of oils for known levels of water.

3.1.1 HTFPU Testing

The hand-held water analyzer will be tested first on transmission oil (MIL-L-85734) in conjunction with the HTFPU being evaluated at NAS JAX. When a helicopter transmission is scheduled to be drained, the oil shall be collected in the 5-gallon closed-top cans that have been provided. For the purposes of this test plan, the collected oil shall be called an "oil sample." After the oil has been collected, at least 2 specimens will be collected in the ½-gallon sample cans provided. The ½-gallon sample cans will be packaged into the shipping containers provided and sent to the Fuels and Lubricants Division located at Naval Air Warfare Center Aircraft Division Patuxent River (NAVAIR PAX). For the purposes of this test plan, the ½ gallon samples shall be called "laboratory samples" or "lab samples."

Unpurified lab samples of helicopter transmission oil and purified lab samples (collected from the HTFPU) will be tested using the hand-held water analyzer. These lab samples will then be sent to the Fuels and Lubricants Division (AIR-4.4.5) at NAVAIR PAX, where they will undergo water content testing by the Karl Fischer method (AquaTest 8) as part of the data gathering process for the HTFPU initiative.

The results of the hand-held analyzer analysis will then be compared to those from NAVAIR PAX AquaTest 8 to assess the accuracy and repeatability of the hand-held analyzer. In addition, data related to fleet labor effort, laboratory labor effort, and laboratory waste generation will be collected to determine both the cost effectiveness of the hand-held analyzer and the ease with which it can be integrated into Navy operations. ***At no point during either phase will purified oil from these tests be returned to any aircraft. After purification, the oil is to be handled and disposed of in accordance with local procedures.***

3.1.2 NOAP Lab Testing

Following this fleet test of the hand-held analyzer, a second unit will be tested at the NOAP laboratory in Philadelphia to determine whether it has the ability to augment the lab's current method of testing for water (the Aquatest 8 Karl Fischer unit).

During this portion of the testing, the hand-held analyzer will be tested for accuracy, repeatability of results, ease of use, labor cost savings, reduction of hazardous material usage, and reduction of hazardous waste generation. Laboratory personnel will analyze various lab samples using both the hand-held analyzer and the Aquatest 8. In addition to analytical results, personnel will record data related to material usage, waste generation, maintenance requirements and reliability, and labor requirements for both methods. This data will be combined with user comments on ease of operation to determine the applicability of the hand-held analyzer in a laboratory setting.

The laboratories will test for accuracy and repeatability of water results in the following oils:

<u>NAVAIR Patuxent River</u>
- MIL-L-85734 - transmission fluid
- MIL-PRF-83282 - hydraulic fluid
- MIL-PRF-87252 - coolant fluid
- MIL-H-17111 - hydraulic oil

<u>Philadelphia NOAP Lab</u>
- MIL-L-9000 - lubricating oil, shipboard internal combustion engine
- MIL-L-17331 - lubricating oil, steam turbine and gear
- MIL-PRF-17672 - hydraulic fluid, petroleum
- MIL-H-19457 - hydraulic fluid, fire-resistant
- MIL-PRF-23699 - lubricating oil, aircraft turbine engine
- PR 1192 - hydraulic fluid

To determine accuracy and repeatability, some lab samples will be tested as they come in from the fleet with unknown water concentrations. To determine the hand-held analyzer's range of effective operation, additional oil samples will be "spiked" with varying quantities of water. All samples will be tested with the hand-held analyzer and then tested with the Aquatest 8 method to confirm water content.

The objectives of the NOAP lab testing include:

- **Reduce the frequency of samples collected in the field that must be analyzed by the NOAP lab.** A field test using the hand-held water analyzer will indicate the water content on a regular basis. A sample will be necessary only when the water content in the oil reaches a predetermined concentration, thus reducing the "blind" samples sent when water concentrations may still be acceptable. The lab will

establish a go/no-go threshold for submitting a lab sample. Additional go/no-go input will be derived from specific aircraft Cognizant Field Activity (CFA) since acceptable water levels in oil may differ by aircraft. Reducing the frequency of samples collected will result in fewer sample containers used, as well as labor, solvents, and consumables used in the evaluation of the sample at the lab.

- **Replace certain uses of the Aquatest 8.** The data derived from the hand-held analyzer might prove to have an acceptable equivalence with the data derived from the Aquatest 8. Eliminating the Aquatest 8 for certain applications will result in reduced labor, solvents, hazardous waste disposal, and consumables related to the Aquatest 8 sampling method.

- **Eliminate the requirement to draw samples from the transmission to determine water concentration.** The manufacturer of the hand-held water-in-oil analyzer is researching a unit that can be mounted with a probe directly into the transmission and that can directly read the water concentration in the oil without actually removing a sample from the transmission. Eliminating the need to collect a sample will reduce labor, eliminate the use of sample containers, and eliminate the need to dispose of used oil.

4.0 Data Collection

Data from the laboratory portion of the testing will be recorded on the supplied data sheet (Table1). Data generated from NAS JAX squadron personnel will be recorded on the Oil Purifier/Water-in-Oil Analyzer Data Sheet (Table 2). The Maintenance and Repair Log (Table 3) will be completed when an equipment failure or scheduled maintenance occurs.

4.1 Instructions for Completing the Water-in-Oil Analyzer Laboratory Data Sheet (Table 1)

The Water-in-Oil Analyzer Data Sheet (Table 1) will be used by NOAP laboratory personnel during the lab test period. In addition, laboratory personnel will be required to submit a list of all consumable materials (with amounts) that are needed to perform water content analysis on one sample using the Aquatest 8 system.

General Data

- **Laboratory:** Enter the name of the lab conducting the testing.

- **Date:** Enter the date (in MM/DD/YY format) on which the sample was analyzed.

- **Analyst:** Enter the name(s) of the individual(s) who performed the testing.

- **Sample ID:** Enter the ID of the sample being tested. If the sample was shipped to the lab from the fleet or from the HTFPU program, the sample ID should reflect that

which was assigned by the shipper. If the sample was spiked in the lab, the sample ID should be a unique sequence created by lab personnel.

- **Type of Oil:** Indicate the type of oil being sampled. See Section 3.1.2 of this test plan for a list of oils.

- **Type of Sample (F/H/S):** Indicate by marking an "F" if the sample came from the fleet, an "H" if the sample came from the HTFPU program, and an "S" if the sample was spiked. Additionally, if the sample was spiked, indicate the concentration of water with which it was spiked.

Pall Hand-held Analyzer Testing Data

- **Time of Analysis:** Enter the total time (in minutes) required to complete the analysis of the sample using the hand-held analyzer. Include all sample preparation and cleanup time in this total.

- **Water Content:** Enter the water content result (in ppm) returned by the hand-held analyzer.

- **Oil Temperature:** Enter the temperature of the oil returned by the hand-held analyzer.

- **Volume of Waste Disposed:** Record the volume of waste generated (in milliliters) as a result of performing the water content analysis on this sample with the hand-held analyzer.

Aquatest 8 Testing Data

- **Labor Time for Analysis:** Enter the total active time (in minutes) spent by laboratory personnel during the analysis of the sample with the Aquatest 8 system. Include all sample preparation time and cleanup time in this total. Do not include time when the Aquatest 8 system is operating without active operator/analyst interaction.

- **Total Time of Analysis:** Enter the total time required (in minutes) to complete the analysis of the sample using the Aquatest 8. Include all sample preparation time, cleanup time, the time it takes for the Aquatest 8 to stabilize, and the time when the Aquatest 8 is operating without active operator/analyst interaction in this total.

- **Water Content:** Enter the water content result (in ppm) returned by the Aquatest 8 system.

- **Volume of Waste Disposed:** Record the volume of waste generated (in milliliters) as a result of performing the water content analysis on this sample with the Aquatest 8 system.

Comments

Record any comments regarding the comparative ease of use of the two water content analysis methods tested. In addition, list any comments, general and specific, that pertain to the condition of the hand-held analyzer, how it is operating, or how it could be improved or made more efficient.

4.2 Instructions for Completing the Oil Purifier/Water-in-Oil Analyzer Data Sheet (Table 2)

Table 2 will be used by NAS Jacksonville personnel when purifying oil through the HTFPU. Each sheet will be used to record usage data for the purification unit and the hand-held water analyzer. During the test period, Table 2 will be completed every day that the HTFPU and/or water analyzer is used and on those days that the HTFPU and/or water analyzer is being repaired or maintained.

- **Date**: Indicate the date (month/day/year) on which the oil sample was run through the purifier.

- **Operator(s) and Squadron**: Enter the name(s) of the individual(s) and the squadron that performed the testing.

I. Aircraft Information

- **ACFT Model and Tail No**: Enter the model and tail number of the aircraft from which the oil sample was taken.

- **XMSN S/N**: Enter the serial number on the transmission of the aircraft from which the oil sample was taken.

- **Oil Drain Date**: Enter the date the oil was drained from the transmission.

- **Time Since Overhaul and Oil Change**: Enter the time since an overhaul and an oil change were performed on the equipment.

II. Purifier Equipment Usage Data

- **Volume of Oil Sample Processed**: Enter the volume of the oil sample (in gallons) that will be run through the HTFPU.

- **Start Time**: Using military time, indicate the time the purifier unit was turned on and began filtering (i.e., beginning of first pass).

- **Upper Pressure and Lower Pressure**: Toward the end of the test's third purification pass (while the unit is still running), record the pressure on the two gauges of the HTFPU. The upper gauge (near the top of the unit) measures the fluid pressure before the fluid enters the filter. Enter the value from this gauge on the Upper Pressure line. The lower gauge (near the bottom of the unit) measures the fluid pressure after the fluid leaves the filter. Enter the value from this gauge on the Lower Pressure line. The difference between the two pressures (ΔP) is an indicator of both the life remaining in the filter and the filter's performance. A high ΔP (35 lb.) denotes a clogged filter that may need to be replaced. The two gauges must be read and recorded in psi.

- **Finish Time**: Using military time, indicate the time the purifier unit was turned off and stopped filtering (i.e., end of third pass).

- **Was the HTFPU operating properly?**: This question refers to whether the HTFPU was not used because it was undergoing repairs, normal maintenance, or filter replacement. If the equipment is not operating properly and the drained oil cannot be purified, save the unpurified oil in a secure location until after the unit has been serviced. Describe the failure in the space provided and complete Table 3 – Maintenance and Repair Log. ***NOTE: If the HTFPU requires repairs, they should be arranged through Donna Switzer, UTRS (856-667-6770), or Raymond Wendrzycki, NAVAIR Lakehurst (732-323-1666 or DSN 624-1666).***

III. Water-in-Oil Analyzer Usage Data

- **Water Reading**: Enter the value that was displayed by the hand-held water analyzer. This value is the water content of the oil in parts per million (ppm). Enter one value for each analysis that was performed (i.e., unpurified lab sample, after each purification pass, and the purified lab sample).

- **Lab Sample ID**: Enter the laboratory sample ID number. The ID consists of the calendar date, in MMDDYY format, followed by a code of U or xP. "U" stands for an unpurified lab sample and "P" for a purified lab sample. The "x" indicates the number of passes through the purifier, usually 3 unless otherwise directed. This number should be the same number that is put on the laboratory sample container.

- **Was the water analyzer operating properly?**: This question refers to whether the water analyzer was not used because it was undergoing repairs or normal maintenance. If the equipment is not operating properly and a reading cannot be taken, the oil should still be purified and lab samples collected and sent to the laboratory. Describe the failure in the space provided and complete Table 3 – Maintenance and Repair Log. ***NOTE: If the water analyzer requires repairs, they***

should be arranged through Donna Switzer, UTRS, or Raymond Wendrzycki, NAVAIR Lakehurst.

Operator Comments and Suggestions Regarding the HTFPU and the Analyzer

Comments should focus on explaining any problems, repairs, when and what maintenance was performed to the purifier system, costs incurred, and any comments or suggestions about the purifier systems' effectiveness and efficiency. In addition, list any comments, general and specific, that pertain to the condition of the water analyzer, how it is running, how it could be improved or made more efficient, and any other applicable/relevant comments.

4.3 Instructions for Completing Maintenance and Repair Log (Table 3)

When an equipment failure occurs, complete Table 3 – Maintenance and Repair Log.

If the failure or scheduled maintenance occurred while processing an oil sample, complete the following:

- **ACFT Tail No**: Enter the tail number of the aircraft from which the oil sample was taken.
- **XMSN S/N**: Enter the serial number on the transmission of the aircraft from which the oil sample was taken.
- **Laboratory**: Enter the name of the lab conducting the analysis when the failure or scheduled maintenance occurred while an oil sample is being processed at a NOAP laboratory.

If the failure or scheduled maintenance occurred unrelated to processing an oil sample, indicate N/A in the previous sections and complete the following:

- **Date**: Enter the date on which the failure or scheduled maintenance occurred.
- **Unit**: Indicate which unit failed or required scheduled maintenance: the HTFPU or the water analyzer.
- **Description:** Describe the repair or maintenance performed.
- **Equipment Downtime:** Indicate how many hours the equipment was not operational.
- **Parts Required:** Indicate the parts required to fix or maintain the equipment.

- **Scheduled Maintenance:** Was this a scheduled maintenance? The maintenance schedule can be found in the operating manual sent by the manufacturer with the equipment.

- **Time Spent:** How many man-hours were spent correcting the problem or performing scheduled maintenance?

5.0 REPORTING

The Oil Purifier/Water-in-Oil Analyzer Data Sheet and the Maintenance and Repair Log should be completed every day that the HTPFU and water analyzers are used, checked, and/or serviced. The Laboratory Water-in-Oil Analyzer Data Sheet (Table 1) is to be completed by NOAP laboratory personnel only on those days that water content testing is performed in the laboratory. Data sheets and Monthly Consumables/Disposal sheets should be faxed, as they are completed or on a monthly basis at a minimum, to Raymond Wendrzycki at 732-323-4179 (fax) and 732-323-1666 or DSN 624-1666 (phone), and Geneen McQuaid at 856-667-7586 (fax) and 856-667-6770 (phone). The final report will include detailed results and observations, assess the efficiency and cost-effectiveness of the unit, and evaluate its transferability to operational squadron sites.

TABLE 1
WATER-IN-OIL ANALYZER LABORATORY DATA SHEET

Laboratory: _____

Date	Analyst	Sample ID	Type of Oil	Type of Sample (F/H/S*)	Pall Hand-held Analyzer				Aquatest 8			
					Time of Analysis (min.)	Water Content (ppm)	Oil Temp	Volume of Waste Disposed (ml)	Labor Time of Analysis (min.)	Total Time of Analysis** (min.)	Water Content (ppm)	Volume of Waste Disposed (ml)

*Mark an "F" if the sample came from the fleet, an "H" if the sample came from the HTFPU program, and "S" if the sample was spiked; and record the amount of water with which it was spiked.

** Include the time it takes to stabilize the equipment.

List of all consumable materials (with amounts) that are needed to perform water content analysis on one sample using the Aquatest 8 system.

_____

_____

Analyst comments: _____

_____

TABLE 2
OIL PURIFIER/WATER-IN-OIL ANALYZER DATA SHEET
PHASE II FLEET TESTING ONLY

Date: _____ Operator(s): _____
Squadron: _____ Operator(s): _____

I. Aircraft Information

ACFT Model: _____ Oil Drain Date: _____
ACFT Tail No.: _____ Time Since Overhaul: _____
XMSN S/N: _____ Time Since Last Oil Change: _____

II. Purifier Equipment Usage Data

Volume of oil sample processed (gallons): _____

Start Time: _____ Finish Time: _____

Upper Pressure (psi): _____ Lower Pressure (psi): _____

Was the HTFPU operating properly (circle one)? Y**es** **No**
If the equipment was not operating properly, complete Table 3 – Maintenance and Repair Log.

Description of Failure: _____

III. Water-in-Oil Analyzer Usage Data

	Unpurified	**Pass 1**	**Pass 2**	**Pass 3**
Water reading (ppm)				
Lab Sample ID				

Was the water analyzer operating properly (circle one)? **Yes** **No**
If the equipment was not operating properly, complete Table 3 – Maintenance and Repair Log.

Description of Failure: _____

Operator Comments and Suggestions: _____

_____

Add additional sheets as necessary

Fax to: Raymond Wendrzycki at (732) 323-4917 and Donna Switzer at (856) 667-7586

TABLE 3
MAINTENANCE AND REPAIR LOG

ACFT Tail No.* _____ Laboratory**: _____

XMSN S/N*: _____

Date	Unit (HTFPU, water analyzer)	Description	Equipment Downtime (hours)	Parts Required	Scheduled Maintenance (Y or N)	Time Spent (man-hours)

*This information is required only if the failure or scheduled maintenance occurred in relation to processing an oil sample.
**This information is required only if the failure or scheduled maintenance occurred while being used at the NOAP Laboratory.

NOTE: If the HTFPU or the water analyzer requires repairs, they should be arranged through Donna Switzer, UTRS, Inc., (856-667-6770) or Raymond Wendrzycki (732-323-1666 or DSN 624-1666).

Fax to: Raymond Wendrzycki at (732) 323-4917 and Donna Switzer at (856) 667-7586.